Operating Systems, Spring 2020, Exercise 3

1. Memory management and virtual memory
    a. What memory management problem is solved with Buddy System? How is it done?
    b. Why do you add segment address and displacement (segmented virtual memory), but concatenate page frame number and displacement (paged virtual memory)?
    c. Assume, that you have paged physical memory (page size 4KB), and you have a reference to variable X in address 0x10005678. Where is X stored in physical memory? How do you find out?
    d. Assume, that you have segmented physical memory with 16 segments (1 MB segment 0 for PCB, 4MB segment 1 for code, 2 MB segment 2 for data, 256KB segment 3 for shared memory, 128KB segment 4 for constants, and no other segments in use now), and you have a reference to subroutine Sort in address 0x10005678. Where is Sort stored in physical memory? How do you find out?
    e. Explain thrashing.
    f. What is the principle of locality and why is it important to virtual memory?
    g. What are the elements typically found in page table entry?
    h. What is the cost of TLB miss, cache miss, page fault?
    i. Is TLB based on spatial or temporal locality? Why?
    j. What is accomplished by page buffering?
    k. What is the difference between a resident set and a working set?
    l. Why do you add segment address and displacement (segmented virtual memory), but concatenate page frame number and displacement (paged virtual memory)?

2. Suppose that a machine has 32-bit virtual addresses and 24-bit physical addresses. Assume also that the page size is 4KB.
    a. How many entries are in the page table if it is single-level? Explain.
    b. How many entries would inverted page table have? Explain.
    c. How many entries are needed in two-level paging in the case the program and data fit together in the lowest page (addresses 0 -4095) and the stack fits to the highest page?

3. Clock algorithm.
    a. Give a simple example of page reference sequence where the first page selected for replacement will be different for the Clock and LRU page replacement algorithms. Assume that the process is allocated 3 frames, and the reference string contains page numbers from the set 0,1,2,3. (Tanenbaum)
    b. If modified bit also used with clock algorithm, then frames can be classified in 4 categories (Ch 8.2). What are these categories? In which order is next page to replace selected from these categories?

4. (Problem 8.4 [Sta12])
   Consider the following string of page references: 7, 0, 1, 2, 0, 3, 0, 4, 2, 3, 0, 3, 2.
   Complete a figure similar to Fig. 8.14, showing the allocation for:
    a. FIFO (first-in-first-out)
    b. LRU (least recently used)
    c. Clock
    d. Optimal (assume reference string continues with 1, 2, 0, 1, 7, 0, 1)

   List the total number of page faults and miss rate for each policy. Count page faults only after all frames have been initialized. (Problem 8.4 [Sta12])

5. Consider a program which has the two segments shown below consisting of instructions in segment 0, and read/write data in segment 1. Segment 0 has read/execute protection, and segment 1 has read/write protection. The memory system is a demand-paged virtual memory system with virtual

addresses that have a 4-bit page number and an 10-bit offset. The page tables and protection are as follows (all numbers in the table are in decimal):

Segment 0 Read/Execute		Segment 1 Read/Write	
Virtual Page#	**Page frame#**	**Virtual page#**	**Page frame#**
0	2	0	On Disk
1	On Disk	1	14
2	11	2	9
3	5	3	6
4	On Disk	4	On Disk
5	On Disk	5	13
6	4	6	8
7	3	7	12
...	...	...	...

For each of the following cases, either give the real (actual) memory address (in hexadecimal) which results from dynamic address translation or identify the type of fault which occurs (either page or protection fault).

a. Fetch from segment 1, page 1, offset 3
b. Store into segment 0, page 0, offset 16
c. Fetch from segment 1, page 4, offset 28
d. Jump to location in segment 1, page 3, offset 32.

6. PFF
   a. What problem is solved with PFF algorithm?
   b. Is PFF fixed or variable allocation policy? Does it have local or global scope?
   c. How does PFF estimate the working set?
   d. How does PFF behave when working set transfers to a new locality?
   e. What happens if threshold F is too small? What if it is too large?
   f. Why would it be better to have two thresholds? How would they be used? What happens, if the time between page faults is between these two thresholds?